ARTIFICIAL NUERAL NETWORKS (7088CEM)

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TOPIC: WEATHER ANALYSIS WITH ARTIFICIAL NEURAL NETWORK

Abstract

Weather analysis has become one of the most interesting fields to research in modern times. Most of the time researchers tried to make a linear connection between the input data of weather and equivalent objective data. But in the later part after introducing the non-linear characteristics of weather data, the aim has focused on the analysis and forecasting of weather. However, the Artificial Neural Network has developed into a superior method to highlight the structural relationship between the various elements as weather data is nonlinear and monitors an identical unbalanced development. This study analyzes the application of ANN software by evaluating efficient and authentic nonlinear models to analyze the weather. Additionally, relate and assess how well the generated models performed in analyzing the highest temperature for 2009 to July 2020 using various transfer methods, concealed layers, and neurons.

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Introduction

In recent times weather analysis has become an important part of science and technologies and researchers are motivated to further study on this application. Weather analysis is done by taking the secondary data of the present temperature condition of the atmosphere and implementing the scientific technological understanding of atmospheric conditions on how it is going to evolve. Analysis loses accuracy as the interval between the current time and the time for which the forecast is being made widens due to the uncertain notion of the climate, the enormous computing burden anticipated to address the conditions that picture the air, estimation error in the underlying circumstances, and a poor understanding of environmental motions. In this report the weather analysis is done from 2009 to July 2020. The collected data contains every day report from 2009 to July 2020. Analysis of the weather of this particular time can be used to arrange activities around these sensations, as well as to prepare ahead and survive the critical conditions, because of heavy rain, heavy snowy weather and the chill wind significantly restrict the outdoor activities. This weather analysis will be done by utilizing the artificial neural network which has been proposed in order to male weather analysis that are very accurate and to assist in resolving all the associated issues of this report.

Problem and data set

Weather analysis is a part of metrological operation, so it can be considered that there are two types of problems in weather analysis: operational problems and meteorological. The aim is to predict the weather accurately from 2009 to July 2020 but there are some problems which will increase the problems of the climate researchers. The problem of this research paper is to collect accurate data for the forecasting and there are different factors that will increase difficulty for data collection (Moon et al 2019). Greenhouse gas effect is an important substance which has a great impact on nature. Temperature varies in a particular area for the effect of greenhouse gas. Also there are some critical weather conditions which will affect the data collection.

The report is based on the weather analysis of 2009 to July 2020. All the data that will be used in this report to analyze and get the result of the weather forecasting for this report. All the data which are collected for the report is secondary. Secondary data are collected from the various resources

that are present on the internet. From the collected data set an understanding and overview can be done. As the data are from 2009 to July 2020, there are many unnecessary data that need to be pre-processing so the data can be sorted for the required analyzing of weather forecasting. In the dataset all the dates are mentioned from 2009 to July of 2020 and all the related data are provided accordingly. Average temperature of all the days are given in this dataset. Every day and every month from 2009 to July 2020 given from the humidity, barometer and rainfall all the data are given (Mishra et al 2018). These data are sorted according to the requirement and analyzed to measure the possible outcome of the given data. Average and maximum temperature, rainfall, snowfall, humidity all the data are collected and sorted on the basis of weather forecasting. Climate researchers use an artificial neural network system to predict the weather of 2009 to 2020. It is necessary to understand and study all this secondary data that is collected from the internet should be authentic so the forecasting can be done appropriately. The data for the weather prediction model is the first thing researchers do in this module.

Data can take many different shapes, the majority of which are chaotic and shapeless. Rarely do they arrive ready to use. Both large and small datasets have a number of problems, including erroneous fields, extra or missing entries, and values in different formats than what researchers need. Researchers must "clean" the unnecessary data and prepare it for usage in order to get it into a usable or structured form. Cleaning processes that are frequently used include parsing, one-hot conversion, deleting extraneous data, etc. After the data has been cleaned, it may be entered into the linear regression model in this module (ANUSHKA, P. and UPAKA, R. 2020). A connection between a reliant variable and numerous unrelated independent explanatory factors can be formed using a linear approach called linear regression. This is accomplished by drawing a line that most accurately, or with the fewest errors, matches the scatter design. By changing the independent values in the line equation, this provides value predictions, or how much.

The main goal is to establish and get ready an organization that can measure specific climate elements, such as max temperature, min temperature, wind speed, and so on for a specific station and a specific day using the weather from the previous day and 11 years of data for that specific day (Hassanjabbar et al 2022). Because the ANN design is the primary concern of this study, only the maximum temperature has been evaluated. This is because there are several parameters that may be changed and optimized throughput experimentation. Once built, the model can then be similarly fed with more weather variables.

Methods

Atmospheric changes happen rapidly because of the effect of excess greenhouse gasses. Due to the presence of the green gasses, it is quite tough to analyze and predict the accurate weather conditions. This causes frustration to the researchers because greenhouse gasses are outside elements which influence the atmosphere too much and don't follow normal trends. There are many methods for weather forecasting (Al-Kahlout et al 2020). Although Climate researchers normally used three types of methods to accurately predict the atmospheric changes throughout a year. These methods are: climatology, analog and persistence and trends methods.

Climatology method

A direct method for creating a weather forecast is provided by the climatology approach. After evaluating and computing the averages of meteorological data collected over several years, meteorologists employ this procedure. Based on the weather for that day several years ago, they can anticipate the weather for a certain location and day. To forecast the weather for the upcoming labor day, a climate researcher would look at the averages for Labor Day, for instance (Hossain, M.S. and Mahmood, H. 2020). The climatology approach works when weather shapes continue to be constant, but it is not the best option for predicting the weather in circumstances when external causes frequently affect the weather, such as in climatic changes brought on by global warming, as it is highly likely to be inaccurate.

Analog method

Analog method is a very difficult method that is used to forecast the weather. To make a weather forecast using this method, climate researchers need to find a past day which has similar weather to the recent forecast. This is very difficult for the researchers. That's why analog methods are considered as one of the most difficult methods for weather forecasting. Consider a scenario where According to the latest prediction, the predicted region will see a warm day with a pending cold front. The weather expert may recall a day last month that was comparable, a warm day with an impending cold front that resulted in the development of thunderstorms later in the day. The

analogue comparison allowed the climate researcher to predict the same kind of weather, but even slight variations between the past and the recent weather can alter the results, making the analogue method a questionable choice for creating a weather prediction.

Numerical weather prediction

Numerical weather forecasting completely depends on the computers. Supercomputers with new developed software prediction models collect data for the forecasting and analyze them by the climate researchers. Climate researchers use these supercomputers to make weather forecasting based on a variety of atmospheric parameters which includes temperature, speed of the wind, various pressure, precipitation, heavy snowfalls and other different factors that influence the weather forecasting (Das et al 2018). To make the weather forecast for the day, the climate researchers analyze the data. The accuracy of the forecast depends on the methods that the computer's software uses to forecast the weather. Errors result from equations that lack precision.

Experimental setup

The AI network tool GUI is available in MATLAB 7.6.0 which is used to collect the data and analyze them by using “Artificial Feed-Forward neural Network” with various methods and functions(RB function,LSTM).

Data pre-processing

The artificial neural network has become popular lately because it is one of the most efficient intelligence techniques that is used to reconcile data mining. The amount of the datasets and the data-preprocessing methods employed have a significant impact on the performance of Multi-layer Perceptions trained with Back Propagation ANN approach (Graf et al 2019). This study examines the advantages of pre-processing datasets with various methods in order to enhance ANN conjunction. An essential phase in the data mining process is data pre-processing. Most of the time, data collection techniques are loosely regulated, which leads to differences, difficult data mixtures, lost numbers, etc. Data analysis that has not been carefully isolated for these issues can lead to unclear results. Therefore, before performing any analysis, the presentation and quality of the data

must come first. A neural network's capacity to successfully understand data depends on a number of criteria, including quality, dependability, and obtainability. When there is incorrect information available or noisy and inaccurate data, it is exceedingly challenging to uncover knowledge during training (Wang et al 2019). Although the stages involved in data preparation and filtering can require a significant amount of processing time, once they are completed, the data become more trustworthy and dependable findings are obtained. Three data normalization techniques will be compared in this study: minimum-maximum normalization, z-score normalization, and decimal ranging normalization.

Feature selection

Feature selection is one of the essential for the success of any automated pattern recognition system. Success of any automated design recognition system depends greatly on feature selection. Removing unnecessary features increases a classifier's effectiveness and lowers the price of feature removal (Jabbari, A. and Bae, D.H. 2018). Artificial neural networks are increasingly in demand to solve pattern classification issues. But selecting the right architecture and model from a variety of choices is still an unsolved research issue. The prior multilayer “feed forward neural network” architecture that was introduced for pattern classification has been improved and employed in this work as a tool for feature selection. Feature selection is a practical pre-processing method frequently used on a major range of datasets. Its major objective is to effectively eliminate unnecessary or redundant variables from the input space, which will improve the performance and interpretability of the numerical models created using the existing data.

Extraction

Data extraction is a unique procedure by which the collection and retrieval are done from different resources present in the internet, which are recognized as disorganized and totally unstructured (Barnes et al 2020). Information extraction makes it possible to combine, manage, and update data so that it can be stored in a single location and later amended. These areas might be close by, in the cloud, or a combination of the two. Data is normally taken from various sources. The extraction of data points out and identifies the related data which are collected and then pre-processing it through transformation. Extraction permits various types of data to mix and finally make it suitable

for weather forecasting. There are various benefits of using the extraction tool in the collected dataset for weather forecasting. It provides more control to operate on the dataset. Extraction of data allows climate researchers to migrate the data from various resources outside of the sources of the collected database. It increases the agility of the dataset which will be used to forecast the weather from 2009 to July 2020. Accuracy and precision is one of the important benefits of data extraction. This will reduce the unnecessary data that are not relevant and help for this report.

Results

All the data that are collected to perform this operation by an artificial neural network are done properly. Data is simulated by python in machine learning so all the outcomes of the dataset are accurate and fulfill the requirements of the research paper (Taherei et al 2018). To study the suggested system a dataset is collected. The dataset consists of all the observations and data from 2009 to July 2019. This dataset consists of every kind of variable like temperature, pressure, wind speed, humidity, and dew point. All the graphs that are generated are related to this variables and properly discussed.

```
import pandas as pd
import numpy as np
import tensorflow as tf
import seaborn as sns

import time
import datetime
import datetime as dt
from datetime import datetime

import collections
from collections import Counter

import matplotlib.dates as mdates
import matplotlib.pyplot as plt
from matplotlib.pyplot import rcParams
%matplotlib inline
plt.style.use('seaborn-whitegrid')

import tensorflow as tf
from tensorflow import keras
import keras
from keras.models import Sequential
from keras.layers import Dense, Dropout, LSTM, Bidirectional
```

Figure 1: Library importation

(Source: Self-made in google colab)

The library importation can be seen in the figure1. All the coding is done in python programing language.

```
from sklearn.model_selection import train_test_split
from sklearn import linear_model
from sklearn.preprocessing import MinMaxScaler
from sklearn.preprocessing import StandardScaler
from sklearn.metrics import accuracy_score

from scipy.ndimage import gaussian_filter1d
from scipy.signal import medfilt
```

Figure 2: Continuation of Library importation

(Source: Self-made in google colab)

Figure 2 is the continuation of the coding that are provided in figure 1.

```
dataset = pd.read_csv("climate_data.csv")
dataset.head()
```

	Date	Average temperature (°F)	Average humidity (%)	Average dewpoint (°F)	Average barometer (in)	Average windspeed (mph)	Average gustspeed (mph)	Average direction (°deg)	Rainfall for month (in)	Rainfall for year (in)	...	Maximum humidity (%)	Minimum humidity (%)	Maximum pressure	Minimum pressure	Maximum windspeed (mph)
0	2009-01-01	37.8	35.0	12.7	29.7	26.4	36.8	274.0	0.0	0.0	...	4.0	27.0	29.762	29.596	41.4
1	2009-01-02	43.2	32.0	14.7	29.5	12.8	18.0	240.0	0.0	0.0	...	4.0	16.0	29.669	29.268	35.7
2	2009-01-03	25.7	60.0	12.7	29.7	8.3	12.2	290.0	0.0	0.0	...	8.0	35.0	30.232	29.260	25.3
3	2009-01-04	9.3	67.0	0.1	30.4	2.9	4.5	47.0	0.0	0.0	...	7.0	35.0	30.566	30.227	12.7
4	2009-01-05	23.5	30.0	-5.3	29.9	16.7	23.1	265.0	0.0	0.0	...	5.0	13.0	30.233	29.568	38.0

5 rows × 22 columns

Figure 3: climate_data dataset

(Source: Self-made in google colab)

Climate_data is the dataset that is collected for the analysis. The data is from 2009 to July 2020 (Abubakar et al 2018). All the data is secondary and gone through various methods so it can be sorted wisely and unnecessary data can be removed. All the graphs are generated from this dataset.

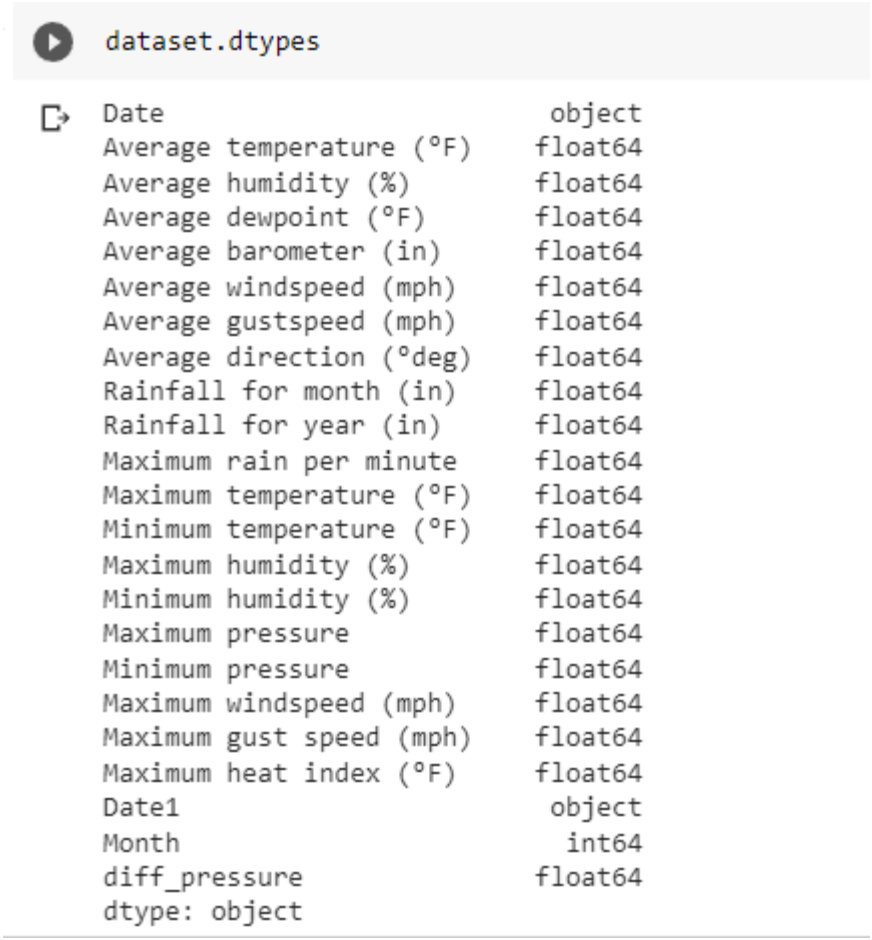
```
dataset.describe().T
```

	count	mean	std	min	25%	50%	75%	max
Average temperature (°F)	3902.0	44.670733	15.326793	-12.100	33.700	45.100	58.0000	76.300
Average humidity (%)	3902.0	48.878011	17.438153	9.000	36.000	47.000	61.0000	94.000
Average dewpoint (°F)	3902.0	23.127037	14.634088	-22.200	12.100	22.500	35.4000	55.100
Average barometer (in)	3902.0	29.881420	0.250395	28.200	29.700	29.900	30.0000	31.000
Average windspeed (mph)	3902.0	5.758893	4.022485	0.000	2.700	4.600	8.0000	26.400
Average gustspeed (mph)	3902.0	10.011968	14.117446	0.000	4.500	7.100	12.1000	240.400
Average direction (°deg)	3902.0	216.037417	97.677761	0.000	116.000	253.000	282.0000	360.000
Rainfall for month (in)	3902.0	0.451105	0.603462	0.000	0.050	0.220	0.6700	4.480
Rainfall for year (in)	3902.0	5.486171	4.534444	0.000	0.980	5.080	9.0475	16.410
Maximum rain per minute	3902.0	0.000000	0.000000	0.000	0.000	0.000	0.0000	0.000
Maximum temperature (°F)	3902.0	57.561661	17.755874	-6.100	43.900	57.250	73.2000	92.700
Minimum temperature (°F)	3902.0	31.227524	14.124424	-27.700	23.000	32.800	41.8000	65.700
Maximum humidity (%)	3902.0	73.673757	20.380611	1.000	63.000	81.000	89.0000	100.000
Minimum humidity (%)	3902.0	26.016914	15.623870	0.000	15.000	22.000	32.0000	90.000

Figure 4: description of dataset

(Source: Self-made in google colab)

This is the description of the collected dataset. All the variables like temperature, humidity, dew point, barometer, wind speed, gust speed and their values are shown in this figure. This data is important to complete the study and make the forecasting authentic.



```
dataset.dtypes
```

```
Date                          object
Average temperature (°F)     float64
Average humidity (%)         float64
Average dewpoint (°F)        float64
Average barometer (in)       float64
Average windspeed (mph)      float64
Average gustspeed (mph)      float64
Average direction (°deg)     float64
Rainfall for month (in)      float64
Rainfall for year (in)       float64
Maximum rain per minute      float64
Maximum temperature (°F)     float64
Minimum temperature (°F)     float64
Maximum humidity (%)         float64
Minimum humidity (%)         float64
Maximum pressure             float64
Minimum pressure             float64
Maximum windspeed (mph)      float64
Maximum gust speed (mph)     float64
Maximum heat index (°F)      float64
Date1                         object
Month                          int64
diff_pressure                float64
dtype: object
```

Figure 5: dataset data types

(Source: Self-made in google colab)

In this figure all the data types of the variables are selected. All the variables will be in float data type except for the month and date. Because month is an integer and date is an object. The generated plot of the dataset are provided below for clear understanding.

```
f,ax = plt.subplots(figsize=(7, 5))
sns.heatmap(dataset.corr(), annot=True, linewidths=.5, fmt= '.1f',ax=ax)
plt.show()
```

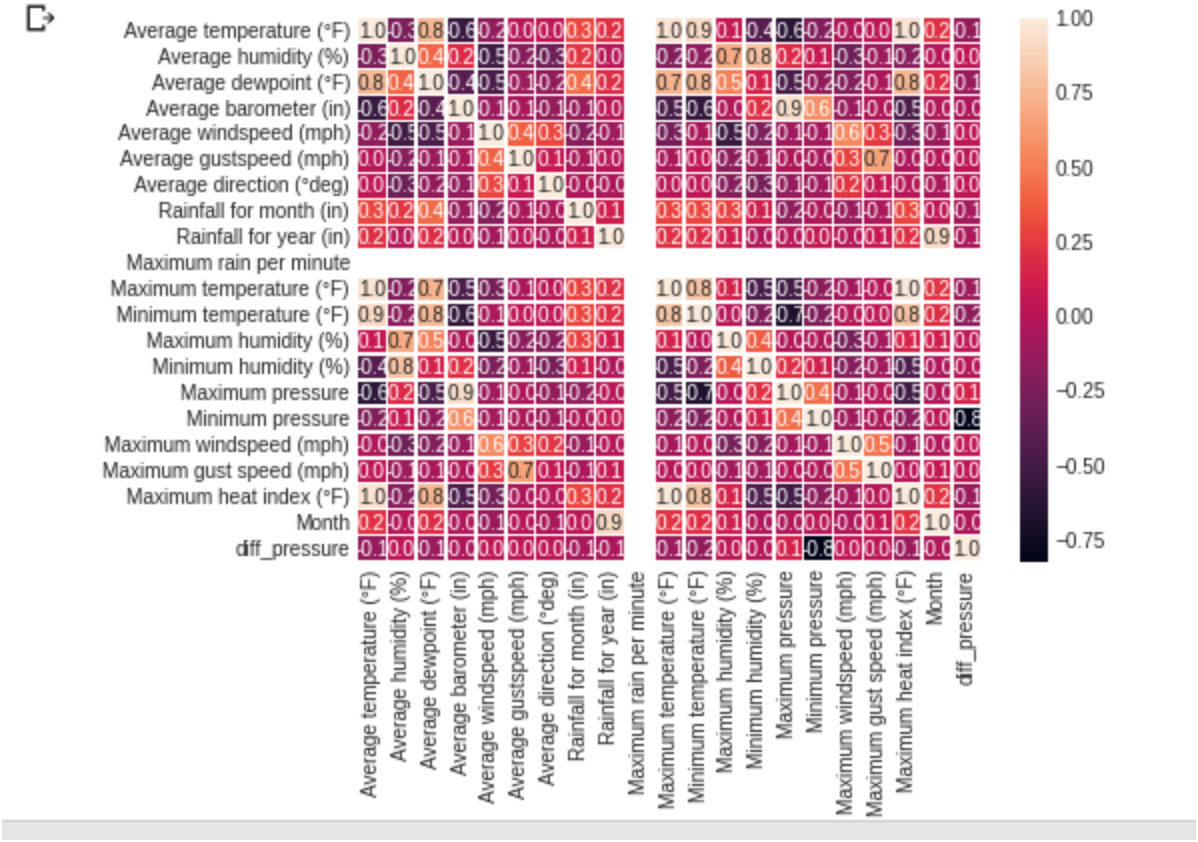


Figure 6: plot of the dataset

(Source: Self made in google colab)

In this figure the whole plot of the dataset is provided. Variables are shown in different colors for better understanding.

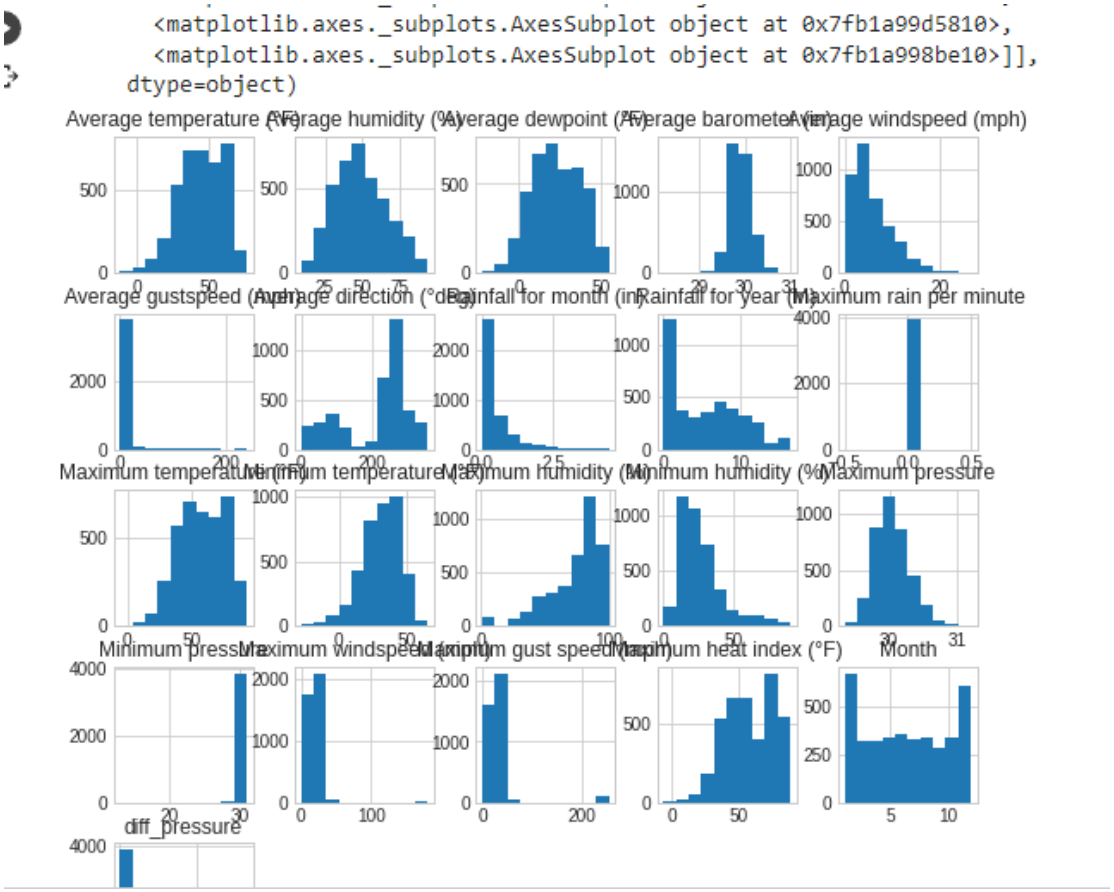


Figure 7: barchart of present variables

(Source: Self-made in google colab)

This is the first bar chart of the present variables. All the present variables from the dataset are shown in this figure with a bar chart.

```
[14] rcParams['figure.figsize'] = 7, 5
     sns.countplot(y=dataset['Average temperature (°F)'])
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7fb1a9399b10>
```

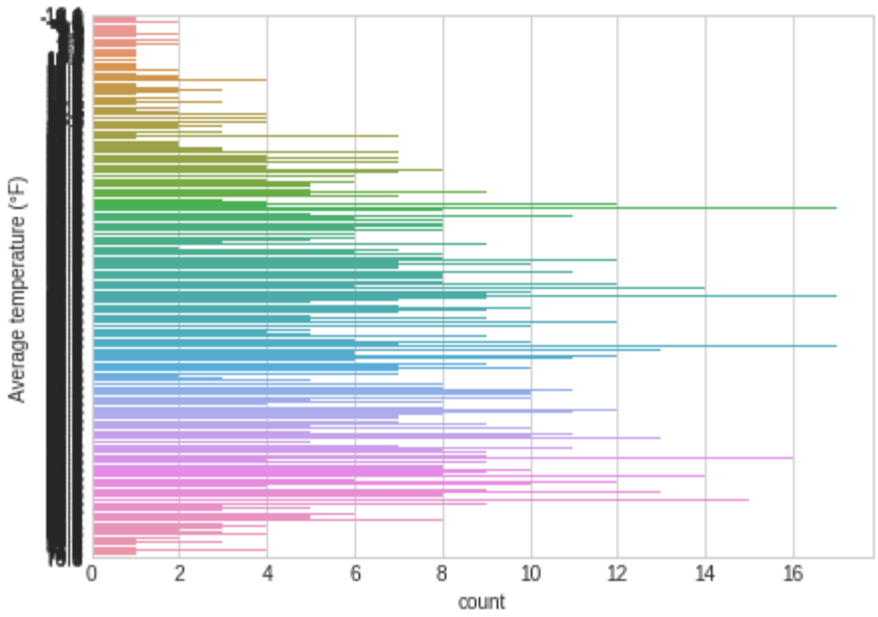


Figure 8: graph of average temperature

(Source: Self-made in google colab)

In this figure a bar chart of average temperature is provided from 2009 to July 2020.

```
(5,5))
t[['Maximum temperature (°F)','Minimum temperature (°F)','Average dewpoint (°F)', 'Average barometer (in)','Average windspeed (mph)','Maximum humidity (%)' ]])
```

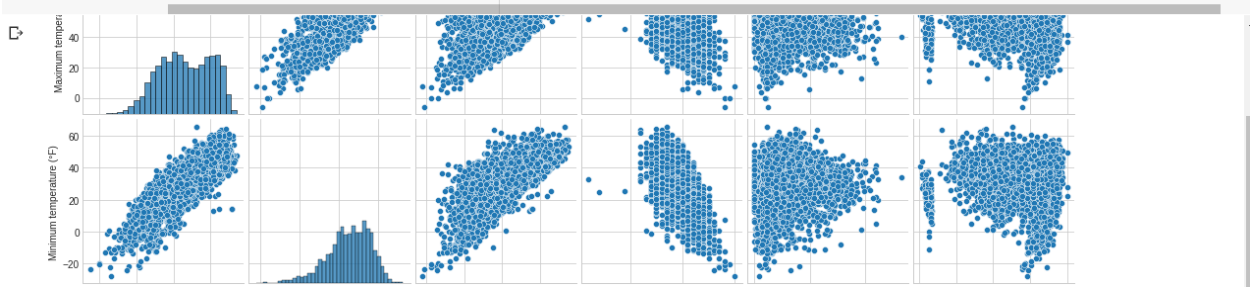


Figure 9: Graph of max and min temp

(Source: Self-made in google colab)

In this figure the graph is generated from the dataset. This graph represents max and min temperature from 2009 to July 2019

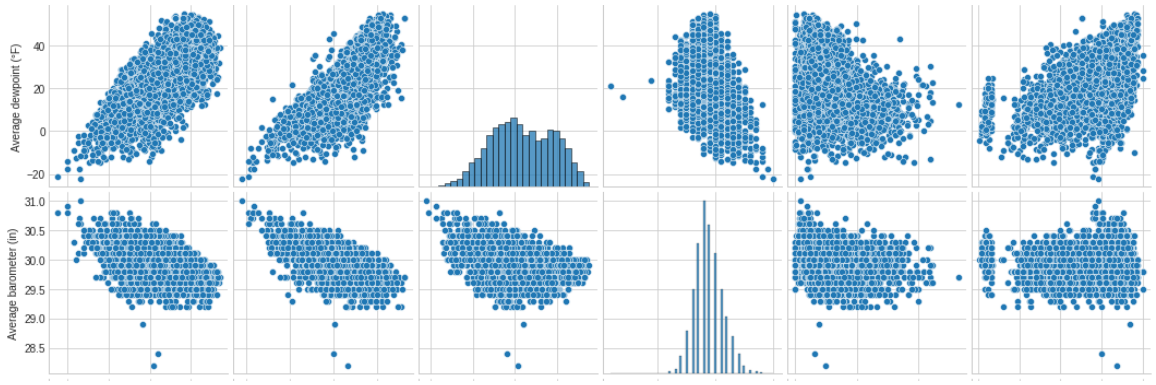


Figure 10: graph average barometer and dew point

(Source: Self-made in google colab)

In this figure the graph are generated by ANN. this graph represents average barometer and dew point.

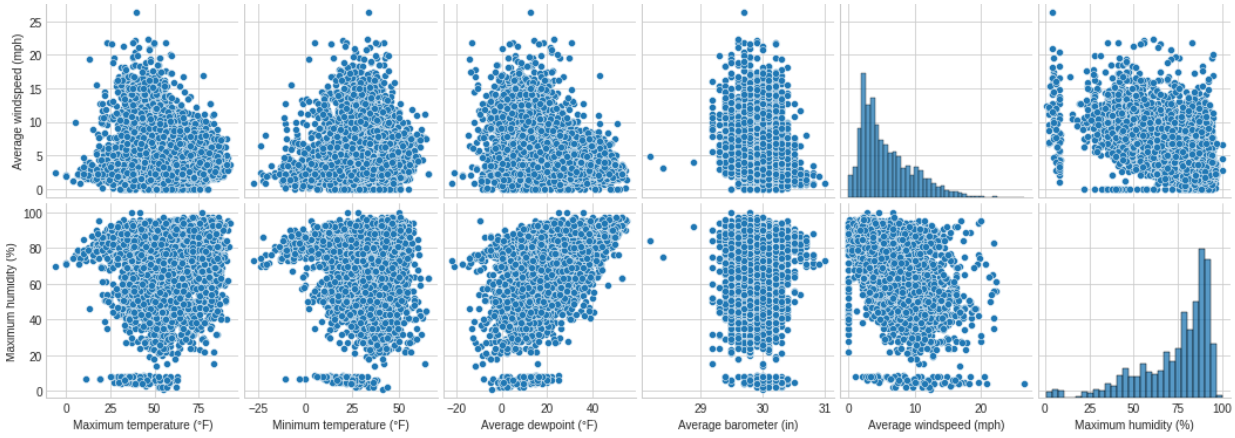


Figure 11: graph of max humidity and average wind speed

(Source: Self-made in google colab)

This figure represents the Maximum humidity and average wind speed of 2009 to July 2019.

```
sns.violinplot(x="Month", y="Minimum temperature (°F)", data=dataset, palette="Set2");
```

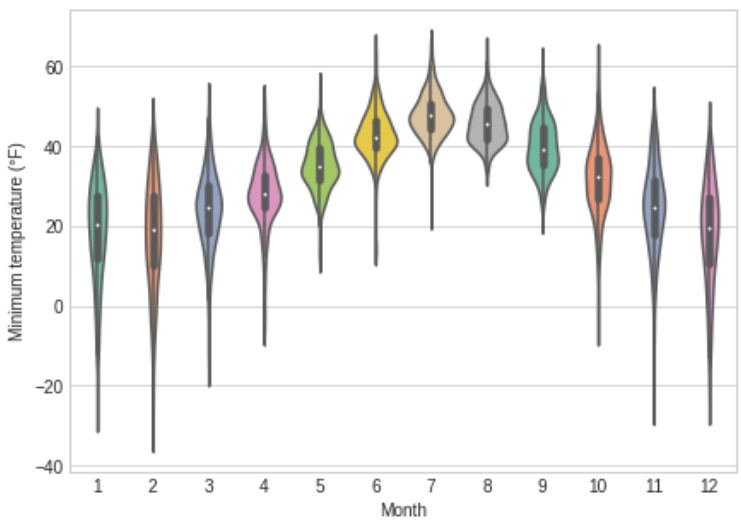


Figure 12: graph of min temp of every month

(Source: Self-made in google colab)

In the figure, a graph of min temperature of every month is generated. This graph represents the month and min temperature of 2009 to July 2019.

```
sns.violinplot(x="Average dewpoint (°F)", y="Minimum temperature (°F)", data=dataset, palette="Set2");
```

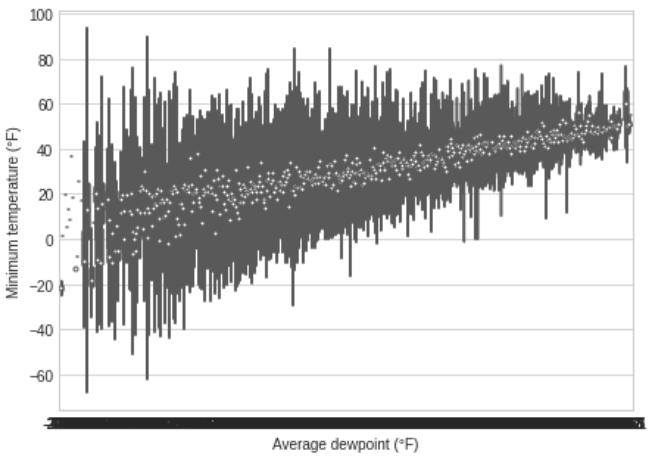


Figure 13: graph of average dew point and min temp

(Source: Self-made in google colab)

This graph is generated by using python language. The figure represents the average dew point and minimum temperature.

```
sns.violinplot(x="Maximum pressure", y="Minimum temperature (°F)", data=dataset, palette="Set2");
```

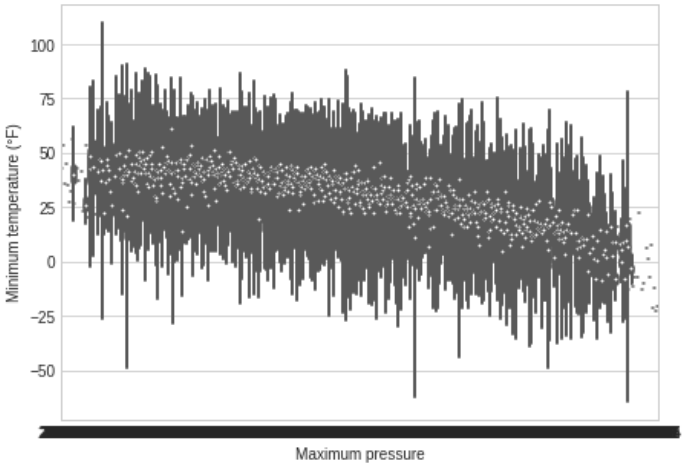


Figure 14: graph of Max pressure and min temp

(Source: Self-made in google colab)

This graph represents the max pressure and min temperature from 2009 to July 2019.

```
[23] sns.violinplot(x="Maximum windspeed (mph)", y="Minimum temperature (°F)", data=dataset, palette="Set2");
```

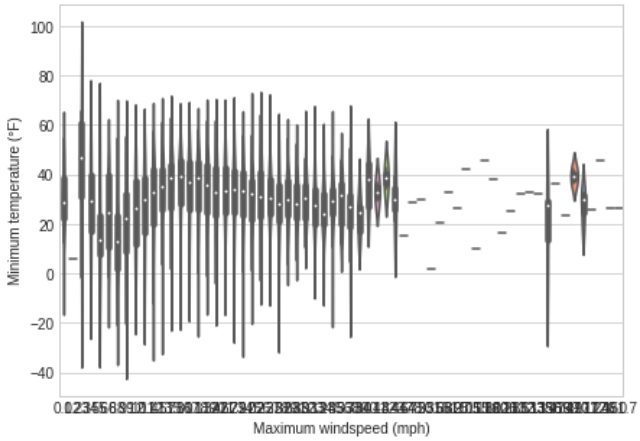


Figure 15: graph of max wind speed and min temp

(Source: Self-made in google colab)

This graph is related to maximum speed and minimum temperature of the collected dataset.

```
[30] loss = history.history["loss"]
     epochs = range(len(loss))
     plt.figure()
     plt.plot(epochs, loss, "ro--", label="Training loss")
     plt.title("Loss of the Model")
     plt.xlabel("Epochs")
     plt.ylabel("Loss")
     plt.show()
```

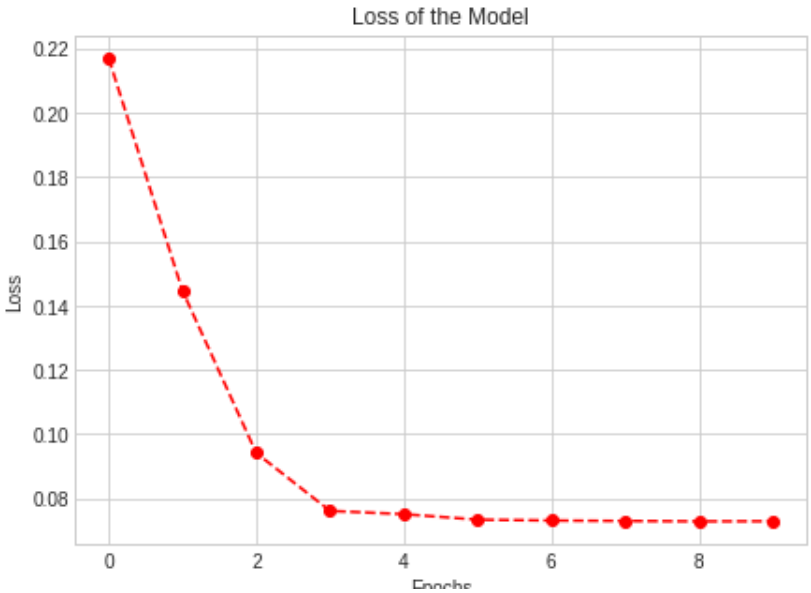


Figure 16: loss of the model

(Source: Self-made in google colab)

At the end of the operation the loss of the dataset is shown. After performing these following operations forecasting will be done accurately.

Social, ethical, legal and professional considerations

Social considerations

Social considerations are one of the most useful methods in weather forecasting. However, it is crucial to consider that the climate researchers can contribute significantly to social sciences research by highlighting the problems to observe the issues in their own nation's warning area. Without the participation and further assistance of the weather community, climate researchers are unable to carry out their work properly (Scher, S. 2018). There are basically three types of social considerations like:

- Communication: communication is a process through which humans can understand each other. Researchers in this field examine how individuals deal with risk, uncertainty, and the visual representations of these ideas. When developing surge maps utilizing visual cartography and graphic design principles, they may conduct interviews with residents of one hurricane-prone area.
- Vulnerability: Weakness is an outlook on the monetary, market, and asset variables that can render someone more vulnerable to harm. A large portion of risk research writing, which deals with extreme weather study, examines the numerous sorts of vulnerabilities that populations and gatherings can have and how that affects their ability to make life-saving decisions, like clear or sanctuary (Al-Dahidi et al 2019). These scientists frequently do research that immerses them in the particular environment they are studying, for example by living locally and carefully observing how people live their lives.
- Forecaster decision making: The focus of sociological research is not, by all accounts, solely on individuals within the general population. Functional meteorologists, who play a crucial role in the advance notice process, encounter extraordinary challenges when trying to decide which data to believe, how to integrate new developments into their approach, and how to communicate their vulnerability and conviction to leaders (Haidar, A. and Verma, B. 2018). Once more, tactics such as chatting or concentrated gatherings, as well as member perceptions in which the analyst sits next to the forecaster and observes that individual at work, might be crucial.

Ethical Considerations

Ethical consideration refers to a group of methods which guide the function and practices of study. Climate researchers need to take special care while they are collecting data for the people. The goals of human inquiry typically include observing actual anomalies, focusing on effective treatments, investigating behavioral patterns, and advancing lives in innovative ways. Main moral considerations include what you decide to research and how you frame that investigation. Ethical considerations mainly focuses on:

- Defend the privileges of research contributors.
- Improve research strength.
- Preserve scientific reliability.

This section of the research paper primarily focuses on the ethical considerations of weather forecasting research.

Legal consideration

This report will shortly cover the present condition of the law relating to weather predictions and cautionary systems, including important cases and legal requirements for a non-attorney audience. The discussion will next focus on the methods in which the law has attempted to handle creative developments like computer and Internet progressions (Huang, C.J. and Kuo, P.H. 2019). The courts and councils have made an effort to either force new damages into the existing legal doctrine or to create new convention that mirrors the changes in the public sight caused by the new advancements. The study will then examine whether this reading of legal requirements in light of modern advancements could result in lately recognized frameworks for gauging and advance notice.

Professional considerations

Professional considerations define a set of methods which are used to govern or monitor the behavior of a group of people in a research atmosphere. Behaviors like: values, rules that consider an individual will act towards the forecasting research, research related peoples, and other aspects of the environment and research.

Discussion and Conclusions

Discussion

To study the ANN system for weather forecasting a dataset is taken from the weather underground. The dataset that is collected has the authentic observation of the weather for a fixed range of time. The proposed dataset of the weather is taken from 2009 to july 2020 on a day-to-day basis. For completing this analysis, overall study of the dataset is necessary so the forecasting can be done properly. The proposed dataset has all the points like temperature, dew point, humidity, rainfall,

wind speed, gust speed on a day to day basis. The results of tests have shown that the key variations in atmospheric pressure signature that are associated with forceful situations of atmospheric circumstances follows for accurate short-term weather forecasting. All the graphs that are generated by using python language. By studying the dataset and generated graphs forecasting will be helpful for the researchers. All the important data from 2009 to July 2019 are analyzed properly to complete this report.

Conclusion

In this study, a back propagation neural network is employed to forecast the temperature using the training data that was given to the network. By putting this into practice. It is demonstrated in the system how an intelligent system coupled with a neural network prediction effectively temperature prediction model. This algorithm gets better convergence that reduces oscillations. The main aim was to analyze the dataset of 2009 to july 2022 for weather forecasting. All the related studies have been discussed and analyzed properly which is related to this project. All the problems related to this project and collected database discussed and solution of the database through ANN also provided in this report. The experimental setup to fulfill the study of the report consists of pre-processing of the dataset, feature selection and extraction of the database. Total understanding of the database which is collected to complete this report are mainly secondary data and authentic. The back propagation neural network's performance in the software tool was satisfactory because there were not a lot of categorization errors. An alternative to conventional meteorological methods for temperature forecasting is the back propagation neural network methodology, which has the potential to produce promising outcomes. With this method, it is possible to identify the nonlinear connection between the collected data provided to the system during training and, using that information, predict what the temperature will be in the future. All the study and calculation are done properly so the forecasting can be authentic and it will help the climate researchers in many ways.

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Appendix

Link To Source Code:

https://livecoventryac-my.sharepoint.com/:u:/g/personal/thomasa26_uni_coventry_ac_uk/EcvBNVoo3xxElde-d2AHBnEBMK4asq0ALK8bkGqSFPFuRw?e=VtB7Bj

Link To Dataset:

https://livecoventryac-my.sharepoint.com/:x:/g/personal/thomasa26_uni_coventry_ac_uk/EQZasa2FkCpKqRQdiSksawoBoCaPC2htzNcFYhHdXHFEzw?e=wRgp3Z